

January 23, 1976.

A Measurement of the A-Dependence of Hadron Production
at large $X_{||}$ and P_t

S. Conetti, C. Hojvat , D.G. Ryan, D.G. Stairs, J. Trischuk

McGill University - Montreal, Quebec

J. Hartmann, J. Orear, J. Vrieslander

Cornell University - Ithaca, N.Y.

M. Gettner, W. Faissler, J. Johnson, D. Potter, E. Pothier

Northeastern University - Boston, Mass.

Abstract

We propose to measure the A-dependence of the production of positively charged hadrons in proton nucleus collisions using the magnetic spectrometer constructed for E-177. The measurements will be made for transverse momenta from 2 GeV/c to 6 GeV/c and for longitudinal momenta extending to the kinematic boundary. Production cross-sections from hydrogen will be extracted over a previously unexplored range of kinematic variables. 200 hours of beam time in Proton West at maximum intensity of 4×10^{11} ppp are requested.

Introduction

The production of particles with large transverse momenta has provided a probe of the deep structure of hadrons. Indeed evidence for "new" physics emerged with the first measurements of the ISR of π^0 production at large P_t .¹⁾ Subsequent measurements at FNAL by the Chicago-Princeton group²⁾ confirmed the result that large P_t production of hadrons was much more probable than expected from a simple extrapolation of the low P_t production data. These experiments utilized heavy targets and in the process of extrapolating results to production from hydrogen, new and unexpected nuclear size effects were found.

Although only limited information exists, the following picture has emerged. Hadron production at large values of P_t does not continue the exponential behaviour seen at small P_t but becomes a power law decrease.

The dependence of the production cross section on atomic number is a function of the kinematic variables. For production in the forward direction, and at high secondary momenta, the single particle production cross-section exhibits an A dependence of approximately $A^{1/2}$.³⁾ At smaller secondary momenta the dependence becomes $A^{2/3}$. For 90° cm production, the power law index is an increasing function of P_t , reaching a limiting value of slightly more than one for large P_t . Finally, this dependence appears to be a very similar for all hadrons, including π^\pm , K^\pm , p^\pm , Λ^0 production.

Models of hadron production fall into two general classes. Hadronic models deal most successfully with small momentum transfer and generally yield an exponential decrease in cross section as a function of P_t .^{4,5,6)} These models involve assumptions about the hadron dynamics. The flux model of Gottfried⁷⁾ has had some success in predicting multiplicities. Recently ideas of Landau and Pomeronchuk⁸⁾ have been reinterpreted for hadron

interactions to give a qualitative picture of the behaviour of hadron production over a broad range of kinematic variables ⁹⁾. Models involving point-like interactions deal with the region of large momentum transfer and yield a power law decrease of the cross section as a function of P_t ¹⁰⁾. Farrar ¹¹⁾ has used these ideas to give a qualitative understanding of the observed A dependence at large P_t .

Independent of considerations of any model, data bridging the region of forward and 90° production in the c.m. will be valuable in understanding the proton ^{nucleus} nucleon interaction. At present, data is confined to regions near $P_t = 0$ and near 90° in the cm. Little is known experimentally of the dependence of particle production over the full range of kinematic variables.

Experiment

We propose to measure the dependence on atomic number, A , of hadron production in high energy proton nucleus collisions. The measurements will cover the kinematic region shown in Figure 1. These measurements will extend the range of $x_t = 2P_t / \sqrt{s}$ and $X_{11} = 2P_{11} \text{ cm} / \sqrt{s}$ over which the A dependence of hadron production is measured.

Yields of positively charged hadrons will be measured for Be, Al, Cu, Sn, and Pb targets. No particle identification will be done. Over most the region of X_{11} covered by this experiment, protons dominate the spectrum of positive hadrons (Figure 2). The secondary momentum will be determined to $\pm 3\%$ or better.

Apparatus

The experiment will utilize the forward spectrometer presently installed in Proton West for E177. The only additional apparatus will be a remote target changer. Five target foils, each 1% interaction length in thickness (Table 1) will be mounted in this target changer. Absolute cross-sections will be determined.

Data Rates and Run Plan

Event rates are based on 1% interaction length targets and a beam intensity of 4×10^{11} ppp. Estimates for the cross sections for positive hadrons are made using the high P_t data of Cronin et al. The invariant cross section is taken to be of the form $E \frac{d\sigma}{d^3p} = \sigma f(x_t)$, independent of X_{11} , assuming the dominant contribution to the rates is protons (Figure 2). The function $f(x_t)$ is obtained from the 400 GeV/c data of Cronin for a W target. Yields for other nuclei are obtained by scaling with A. Table 2 gives the rates per hour obtained. These rates are computed for a bin size of .5 GeV in P_t and 20 GeV in P_{11} . For the low x_t running, beam intensities can be reduced.

The total data taking time required is approximately 160 hours with an additional 40 hours for tuning and testing.

References

- 1) F.W. Busser et al, Phy. Lett. 46B, 471 (1973)
- 2) J. Cronin et al, Phys. Rev. D11, 3105 (1975)
- 3) K. Heller et al, Results from E8 rep
- 4) S. Frantschi, Phys. Rev. D3, 2821 (1971)
- 5) S. Chu and A. Hendry, Phys. Rev. D6, 190 (1972)
- 6) R. Hagedorn and J. Ranft, Nuovo Cimento Supp 6, 109 (1968)
- 7) K. Gottfried, Phys. Rev. Lett. 32, 957 (1974)
- 8) L. Landau and I. Pomeranchuk, Doklady Akad Nank SSR 92, 535 (1953)
- 9) L. Stodolsky, VIIth International Colloquium on Multiparticle Reactions, Oxford (1975)
- 10) R. Blankenbecler, S. Brodsky, and J. Gunion, Phys. Rev. D6, 2652 (1972)
- 11) G. Farrar, CALT -68 -478 (1975)

Table 1 - Targets

<u>Element</u>	<u>Atomic Number</u>	<u>Thickness(cm)</u>	<u>1/1rad (%)</u>
Be	9	0.30	.84
Al	13	0.26	2.8
Cu	63.5	0.93	5.8
Sn	118.7	0.13	10.8
Pb	207.2	0.10	16.0

Table 2 - Data Rates

<u>P_t (GeV/c)</u>	<u>X_{11}</u>	<u>Events/hr/bin</u>	<u># of Targets</u>
5.75	.9	7.7	3
4.60	.8	293	5
4.10	.7	1440	5
4.60	.9	293	5
4.10	.8	1440	5

Data rates for spectrometer settings near kinematic boundary.

Bin size is 0.5 GeV in P_t and 20 GeV in P_{11} .

All other spectrometer settings yield larger event rates.

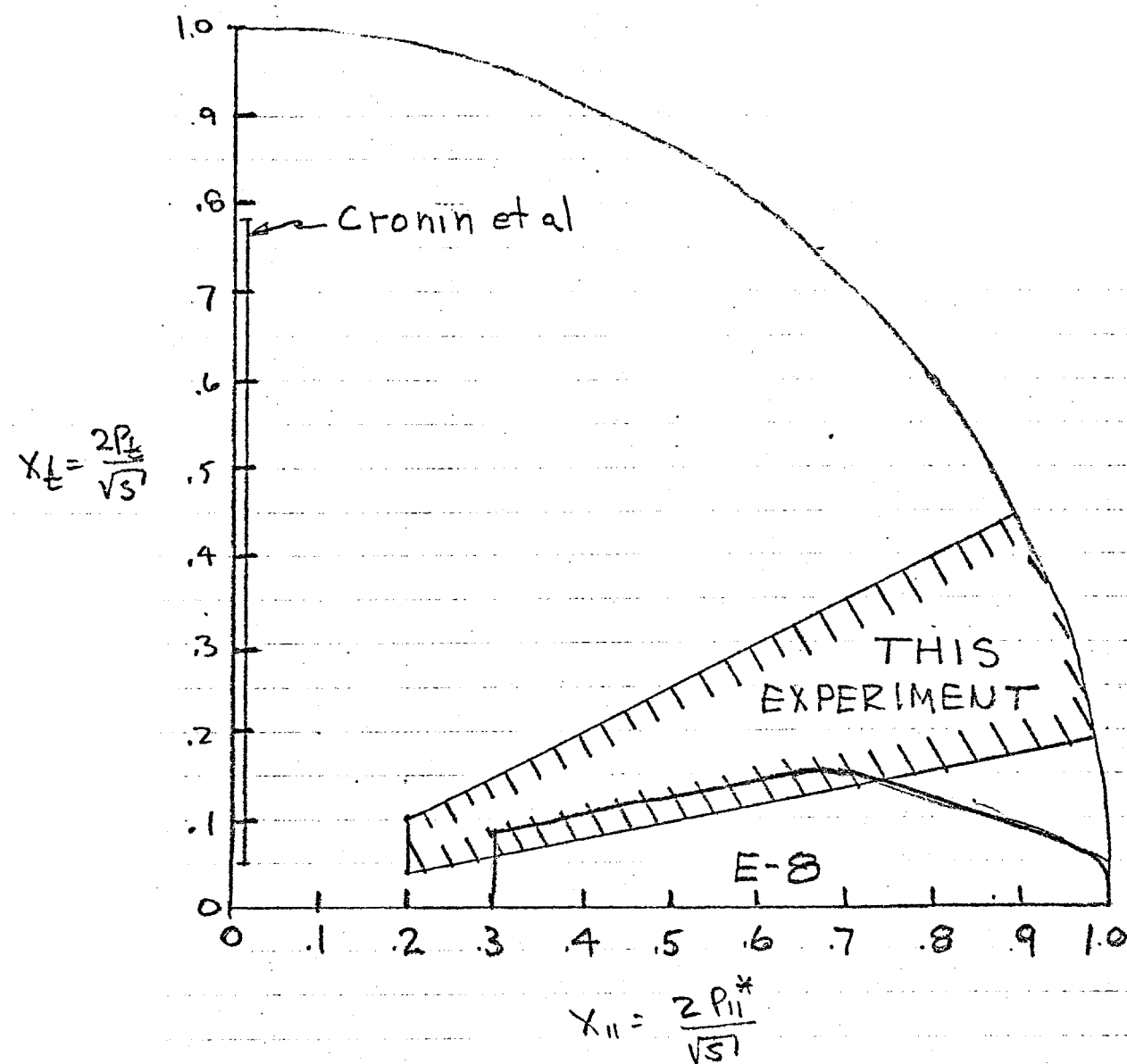


Fig 1

Fig 1 - Region of Coverage of this Experiment compared to other FNAL particle production experiments

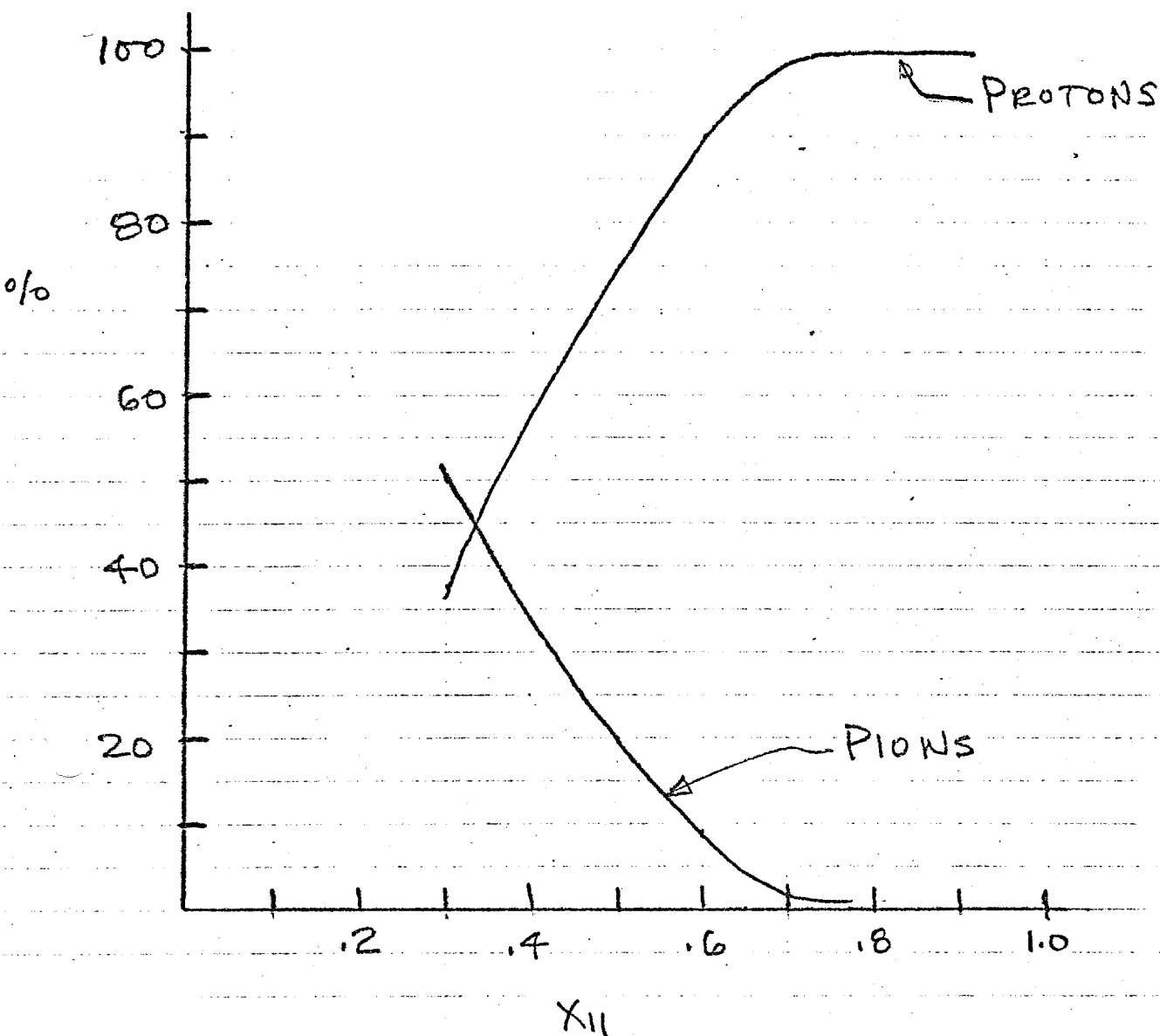


Fig 2 - % of positive hadrons vs X_{11}
(Hagedorn and Ranft)

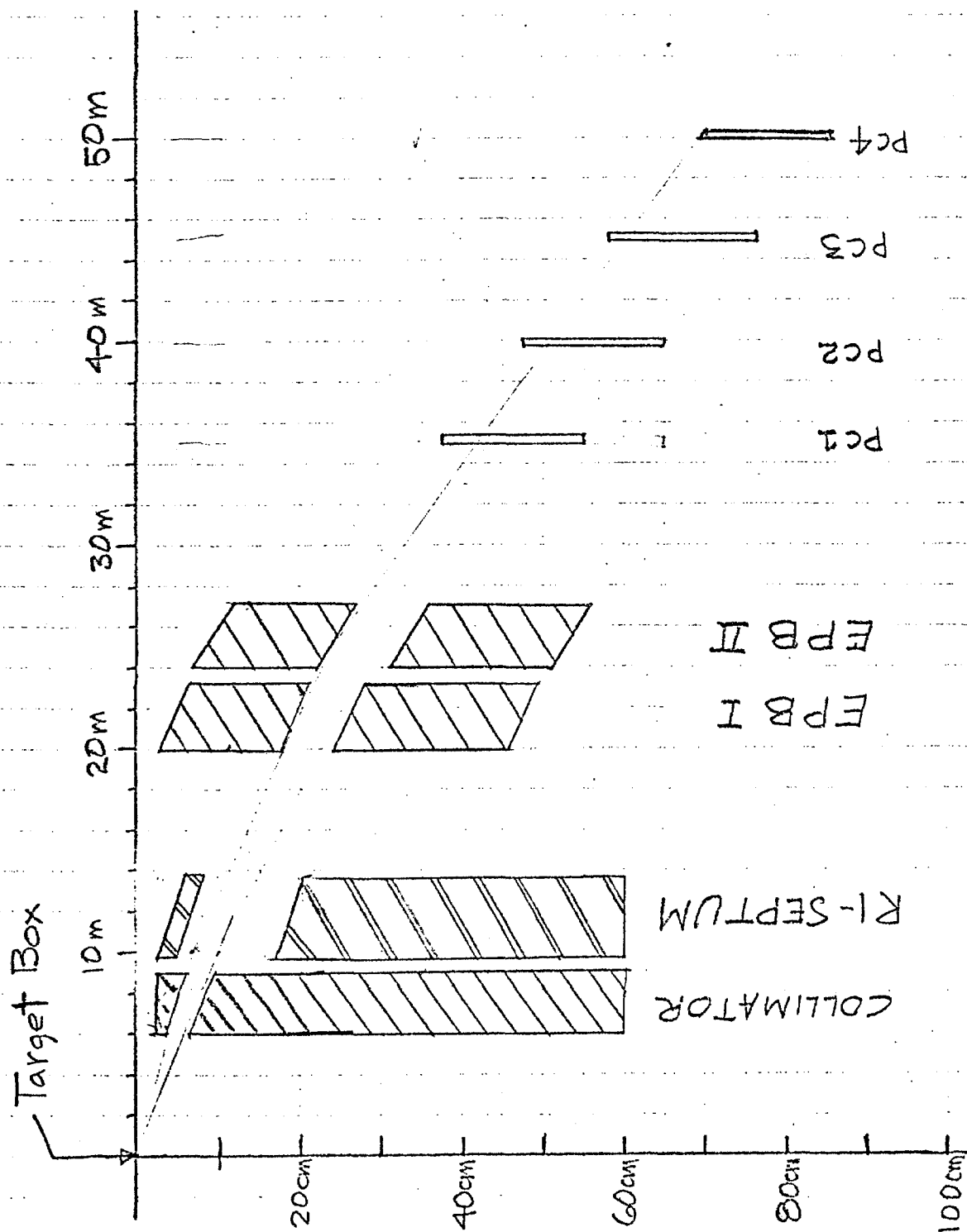


Fig3 - Schematic of Spectrometer (not to scale)